UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 708 FEBRUARY 14, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE LEOPARD MOTH:[1] A DANGEROUS IMPORTED INSECT ENEMY OF SHADE TREES.

By L. O. HOWARD and F. H. CHITTENDEN.

INTRODUCTION.

Along the Atlantic seaboard from eastern Massachusetts to southern New Jersey, and in the Hudson River Valley, shade and ornamental trees and shrubs of many kinds, with the exception of evergreens, are severely injured by the larva or caterpillar of the European leopard moth. Around such centers as Boston and New York, and in the State of New Jersey, this insect constitutes a most serious menace to the growth of shade trees. The larva of the leopard moth does not feed on the foliage, as do most of our shade-tree caterpillars, but bores into the branches and feeds upon the living wood. It usually begins operations in twigs and small branches and trunks; this work has the effect of girdling and so weakens the wood that the portion beyond the injury is often broken by heavy wind storms, while in the case of severe attack, especially to young trees, the growth of the tree is checked and death frequently follows. Attack is not confined solely to shade and ornamental plants, but orchards also are often injured.

DESCRIPTION.

The leopard moth derives its name from the spotted appearance of the adults as illustrated at *a* and *b* in figure 1. There is a great difference in size between the sexes, the female (*a*), which is a heavy-bodied moth and a very feeble flier, being much the larger. The male (*b*), on the other hand, has a more slender body, which insures ready flight, and is further distinguished from the female by the fact that its antennæ, or feelers, are broad and feathery. The wings are semi-

[1] *Zeuzera pyrina* Fab.; order Lepidoptera, family Cossidae. Synonyms: *Zeuzera aesculi* L. and *Z. decipiens* Kirby.

NOTE.—This bulletin is of interest to growers of shade and ornamental trees, especially in the New England and North Atlantic States.

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transparent and white, thickly dotted with blackish spots which are more or less distinctly tinged, giving them a dark-blue or greenish cast. The thorax is white and has six large black spots and one small one, this last being in the center. The abdomen is white, with dark crossbands. The female has a wing spread of something over 1½ inches, while that of the male is much less.

The eggs are oval and salmon colored.

The larva, which is the form that inflicts the injury, is a fleshy, grublike caterpillar of pale-yellow color, very frequently with a pinkish tinge, especially when reaching full growth. The head,

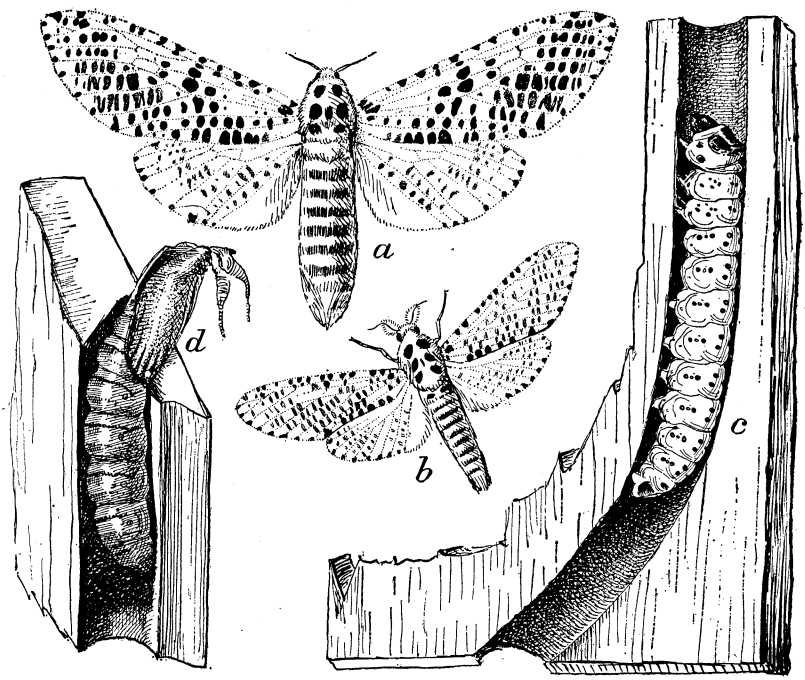

FIG. 1.—The leopard moth (*Zeuzera pyrina*): *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Authors' illustration.)

thorax, and plates on the hind end of the body above are brownish black, and the entire surface of the body is sparsely hairy and covered with large and prominent tubercles arranged as shown in figure 1, *c*, which illustrates the larva in natural position when at work in a tunnel which it has constructed in the solid living wood. When the larva has completed its growth it is fully 2 inches in length.

The pupa, or chrysalis, to which the full-grown larva changes, is very similar to that of other wood-boring caterpillars. On its head is a sharp protuberance which helps it in pushing its way partly out of the burrow preparatory to the emergence of the moth. The

appearance of the pupa is shown in figure 1 at *d*, which illustrates the empty pupal case projecting from the burrow, as the moth has left it.

ORIGINAL HOME; SPREAD AND PRESENT DISTRIBUTION.

The leopard moth, like so many other dangerous pests, is a European species which has been accidentally introduced into the United States in comparatively recent years. Its Old World distribution, as recorded, is central and southern Europe, southern Sweden, southwestern Africa, Algeria, northern Morocco, and the western portion of Asia Minor.

This species was introduced into the United States sometime prior to 1879; in this year a living moth was captured in a spider's web at Hoboken, N. J. In 1887 it was seen at Newark, N. J., but was not actually recorded as occurring in this country until the following year. In 1890 the moths were observed at electric lights at Orange, N. J. In 1894 its destructive ravages were recognized in Central Park, in New York City.

Fortunately the spread of this insect, particularly in the immediate vicinity of New York City, has been very slow, a fact which may be attributed to several causes: (1) The slow and feeble flight of the female, (2) the dominance of sparrows and squirrels in large cities, causing our native birds, such as woodpeckers, to be driven to the country, where they destroyed the moths, and (3) the bowl-shaped electric-light globes, open at the top and closed at the bottom, which were formerly in general use in our large cities. The males are strongly attracted to brilliant lights, and many were captured and perished in these globes in earlier years.

Specimens were collected at Bridgeport, Conn., in 1901. The species now occurs on Staten Island and has spread on Long Island well beyond the confines of greater New York. Southward it was reported a pest, in 1901, at Ocean Grove, N. J., and by 1905 was recorded at Kensico, N. Y., 25 miles north of New York City. By 1907 it was captured at New Haven, Conn. In 1908 it appeared in injurious numbers in the vicinity of Boston, Mass., where it seriously attacked the large elms on the Harvard University campus, and has since spread to more distant localities, specimens having been received from Lynn and from the island of Nantucket. It has been received from at least one locality in Rhode Island. Other towns and cities are indicated on the map (fig. 2), on which the southward limit, Woodbury, N. J., is shown.

On the occasion of a visit to New York City in recent years the junior writer was unable to find this insect or any evidence of its injury in the parks of Manhattan and Harlem. In side streets in the

vicinity of the parks, however, there were signs of extensive injury, and a number of trees had been removed, evidently because of death due to borer attack. Inquiry of the State entomologist and others failed to elicit any information in regard to new localities. The species has not been found in Pennsylvania so far as can be deter-

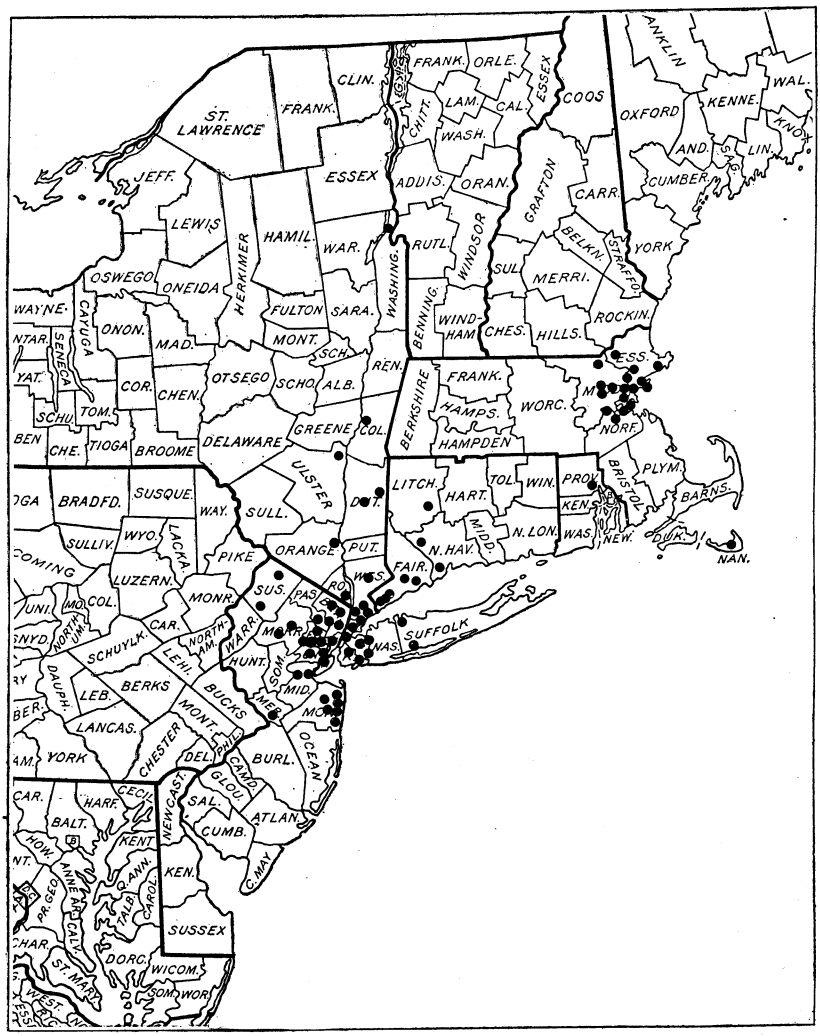

FIG. 2.—Map showing known distribution of the leopard moth in the United States in 1915. (Original.)

mined, nor has it spread to any extent from the localities which have been mentioned.

Information has been received that this species is less serious in its attacks to trees in the vicinity of New Haven, Conn., than it was six or eight years prior to the date of this publication. Taking

everything into consideration, it would seem that the species, while distributed along the coast, will, in time, be greatly reduced in this region, probably by parasites and other natural enemies, and will very gradually spread inland as it is now doing.

FOOD PLANTS.

In its Old World home the leopard moth is recorded as living on a considerable number of common trees, including elm, lime or linden, ash, beech, birch, walnut, oak, chestnut, poplar, alder, and, rarely, horse-chestnut. Among orchard trees it is reported to injure pear, apple, plum, and other fruit trees.

In the United States it attacks all of these trees and in addition practically all of the maples, ash, mountain ash, tulip tree, dogwood, aspen, and willows, such shrubs as privet and lilac, and honeysuckle. A list of 83 trees and shrubs which this larva has been actually observed to attack was compiled in 1894; 77 of these were observed in the public parks of New York City alone. A later list contains 125 species and varieties.

It will be seen by the list of food plants already presented that the number could be almost indefinitely extended, particularly in reservations like Central Park, New York City, and Prospect Park, Brooklyn, where special effort has been made to bring together a great variety of trees and shrubs. The insect will attack practically all forms of woody plants which are of suitable size for its purpose, with the exception of evergreens.

LIFE HISTORY AND HABITS.

In Europe the moths make their first appearance during July and August, but in this country they appear as early as May and continue issuing from the injured wood until late in September.

The female ready for egg laying, being particularly heavy, is unable to fly very far or very high. She deposits her eggs singly and in groups of three to four or more, and as many as 800 eggs laid by a single moth have been counted. The eggs are generally inserted in crevices in the rough bark of trees.

The larvæ hatch in about 10 days, penetrate the wood, frequently entering the nearest crotch, but also boring in at other points, and burrow tunnels into the heart or pith of twigs and the heartwood of the larger branches or trunks. When a larva has grown too large for the branch in which it is feeding it crawls out and enters a larger one. In a single tree 6 inches in diameter as many as six larvæ were observed, any one of which would have been able ultimately to destroy the tree if not removed; in fact, six to eight borers to the tree have been reported as an average in a badly infested location, and in one

instance 34 were found in a single tree. By the time the larvæ within have attained full growth, infested limbs of a certain size are likely to break off, especially during or after a severe storm, for the full-grown larva in many cases girdles the branch. The manner of girdling is shown at the top of the section of wood illustrated in figure 3. In 1893, after every storm in Central Park immense numbers of limbs were seen, some entirely broken off and others still hanging to the trees.

The larva when fully mature transforms to the pupa within its burrow, the change beginning to occur during the second May after the hatching of the eggs. The larva thus requires nearly two years to complete its growth. The pupa, by means of the sharp protuberance on its head, is enabled to force its way partly out of the burrow, after which the skin splits open and the moth emerges. The empty pupal skin remains for some time projecting from the orifice. (Fig. 1, *d*.)

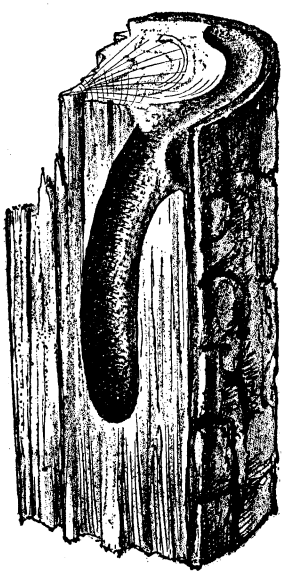

FIG. 3.—Section of wood showing burrow and girdling effect produced by larva of leopard moth. Reduced. (From Insect Life.)

The presence of this borer in a branch is manifested by an accumulation of chips, matted excrement, and frass, which indicates the entrance to the burrow. After a time these holes are closed from within by a silken web, doubtless to protect the contained insect from its natural enemies. Smaller twigs wilt and break off, and often the work of the insect is first recognized only when the severed twigs or branches have been brought down in numbers by high winds. Where the larger larvæ have worked just under the bark this splits open the next season, leaving an ugly scar as a reminder of its pernicious operations. (Fig. 4.)

NATURAL ENEMIES.

No specific natural enemies of the leopard moth other than birds appear to have been recorded in this country, although in Europe three or four wasplike parasites[1] have been reared.

In the explanation of the slow spread of the leopard moth from cities and large towns to the country, allusion has been made to the fact that native birds assist, to some extent at least, in holding

[1] An indeterminate chalcidid of the subfamily Encyrtinæ—perhaps (*Copidosoma*) *Litomastix truncatellum* Dalm.—and *Schreineria zeuzerae* Ashm., *Microgaster* sp., and one proctotrypid.

this insect in check in the suburbs. There are the best of reasons for believing that birds like the woodpeckers, which naturally look over the bark and collect all kinds of borers, prey on this species; even sparrows, it is believed, sometimes destroy the eggs and young larvæ, as they are known to devour the moths. It is also believed that when the insect succeeds in getting away from the outskirts of cities its enemies increase in number, many insectivorous birds aiding in keeping it down.

During the day the moths are fed upon by birds and later by bats and night-flying birds. The habit of the larvæ of deserting one twig and migrating to a larger one undoubtedly leaves them exposed to the same natural enemies, as this migration has been observed to take place in the daytime as well as after nightfall. It follows that the protection of native birds, especially the woodpeckers and those of related habits, will greatly assist in restraining the undue increase and spread of this borer.

Squirrels, especially the gray squirrel, which is becoming common in our large cities, have also been observed feasting on the larvæ, but neither sparrow nor squirrel should be encouraged because of this habit, since both are responsible for driving away many of our native birds.

FIG. 4.—Work of the leopard moth in branch of maple. About natural size. (Original.)

METHODS OF CONTROL.

The protected and concealed manner of life of this borer, as shown by the life history, which will apply in the main to borers in general, renders it very difficult of treatment by means of insecticides or other direct measures. The most efficacious remedial measure consists in cutting off and destroying affected branches and in the injection of bisulphid of carbon into the holes or burrows where the larvæ are at work.

PRUNING AND CUTTING BACK.

Twigs or branches which, by their wilting or by the presence of burrows showing accumulations of frass or sawdust-like castings at their entrances, indicate the presence of this borer should be carefully searched out, the smaller ones pruned away and the larger ones cut back, and the amputated portions promptly burned. The stubs should be coated, preferably with grafting wax, to prevent the entrance of other insects or the spores of decay-producing fungi, although coal-tar preparations containing mineral substances are in somewhat general use for this purpose. After windstorms the affected branches which have fallen to the ground and those which remain attached to the tree should be collected and burned. Wherever trees show that they are past recovery it is best to take them out and promptly destroy them. The word "promptly" is used advisedly, since this insect, as previously stated, frequently migrates from one twig or branch to another.

INJECTING BISULPHID OF CARBON.

In the case of young and rare trees and others which show only a few larval burrows in the bark, bisulphid of carbon is the best remedy and one which has been in general use against the present species in the public parks of New York City. It is injected into the openings of the burrows, and the openings are immediately afterwards closed with various substances. For this injection a mechanic's long-spouted oil can of small size may be used on large trees, but against a related species the writers have made very good use of a small glass syringe, such as may be purchased at drug stores for about 10 cents. These glass syringes are most serviceable, because the exact amount of bisulphid may be seen when drawn into the syringe and because there is no threading to be injured by the reagent. Metal syringes may also be used, but it is more difficult to measure the exact amount, and the bisulphid acts on the leather packing. Rubber syringes are not serviceable because of rapid corrosion. About a teaspoonful of the liquid bisulphid is sufficient for each burrow.

For stopping the holes after injecting the liquid, putty and moist clay, advised by some, have been found practically useless. Grafting wax, on the other hand, gives perfect satisfaction. Coal tar is less advisable but may be substituted for the latter, or the holes may be closed by inserting a wooden plug and breaking or sawing it off even with the trunk. In any case the stopper should be tight, to exclude water from rains, which might tend to produce decomposition of the surrounding wood or invite the entrance of other insects, like carpenter and other ants and secondary borers, of which there are many species, and injurious fungi.

Carbon bisulphid should be handled with the usual precautions against fire, which means that the operator should not smoke while at work. Although the fumes should not be inhaled, as they are poisonous, the liquid will not injure ordinary trees when applied as described and does no harm to the hands.

KILLING WITH WIRES.

It is possible to reach and destroy many larvæ by forcing a copper or other pliable wire into the channels. This is a well-known borer remedy. It is impossible, however, by this means to kill the insects in all cases, owing to the length or crookedness of the burrows. Bisulphid of carbon should then be used.

ATTRACTING TO LIGHTS.

To what extent electric or other bright lights are serviceable as an agency in the destruction of the moths of this borer has not been definitely determined, but they possess a certain value. A method frequently advised consists in placing shallow pans around electric-light poles in and about parks to attract the moths. The pans are partially filled with water, and a small quantity of kerosene is poured into them. The moths flying against the globes drop into the pans and are promptly killed when they come in contact with the oil. In this way many males can be destroyed.

TREE INSPECTION.[1]

In large parks the destruction wrought by this borer annually is an important item, and it will be found profitable to establish a system of inspection consisting in the employment of park keepers

[1] During the last years of the nineteenth century a long row of beautiful red oaks bordering the street between the grounds of the Department of Agriculture and those of the Smithsonian Institution were badly infested by the related carpenter worm (*Prionoxystus robiniae* Forst.). Nearly every tree was infested, and frequently two or three burrows showed near the tops of the trunks. Bisulphid of carbon was applied, as described above, and the holes closed with grafting wax. A year later no insects could be found at work, but wherever this remedy had been applied a small scar remained. Two years later these had entirely disappeared, and the trees looked as if they had never been infested.

and boys and others who may be engaged at lower wages to keep a constant lookout for evidences of borer attack on valuable trees. In 1893 a New York entomologist spent two months in fighting this insect alone in the city parks of New York, collecting wagonloads of limbs and branches and destroying the contained larvæ and pupæ.

MAINTAINING TREES IN THRIFTY CONDITION.

If valuable trees are to be protected, the insect should not be allowed to breed in useless growth. The borers in such trees should be destroyed or the trees promptly felled and burned. Care should be exercised in transplanting trees, and fertilizers should be used in order that the trees may be always thrifty, the better to withstand attack. This also means protection from the attack of aphides, scales and defoliators such as the white-marked tussock moth and the fall webworm, and keeping them free from disease.

PROMPT AND THOROUGH TREATMENT ESSENTIAL.

Finally, in the control of this species promptness and thoroughness can not be too strongly emphasized. The bisulphid of carbon remedy should always be used where applicable, and the inspection system advised should be instituted in all public parks and on city streets infested by this pest. Individual owners of valuable trees should become acquainted with the pernicious nature of this borer, and united action should be secured with neighbors whose trees suffer from the ravages of the pest.

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San Jose Scale and Its Control. (Farmers' Bulletin 650.)
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